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PLANT GROWTH AND YIELD IN THE CAVENDISH BANANA *(Musa cavendishii* Lamb.*)* AS AFFECTED BY SIZE AND TYPE OF PLANTING MATERIAL

By F. W. BERRILL, B.Sc.*

SUMMARY

The effect of size and type of planting material on plant growth and yield in the Cavendish banana has been investigated at the Maroochy Experiment Station using "bits" ranging from 1 lb to 6 lb in weight and "suckers" ranging from 10 in. to 20 in. in maximum girth.

Bits required a longer period to emerge than suckers but produced a uniform stand of plants which were taller, were greater in girth and bore larger bunches than plants grown from suckers. These differences were reflected in the greater number of hands per bunch and the greater number of fingers.

Size of planting material had no appreciable effect on the performance of bits, although plants from the larger sizes matured their bunches a little earlier than those from the smaller. The performance of sucker planting material, on the other hand, varied with size—the smaller the sucker the longer the growing period, the greater the number of leaves and, in general, the greater the bunch weight.

Neither size nor type of planting material had any influence on the total number of suckers produced.

Fruit filling was similar in all types of planting material tested.

From a commercial point of view, bits weighing 2–4 lb appear to be the best type of planting material. Where these are not available, "sword" suckers with a corm girth of 12 in. are preferable to either larger or smaller sizes.

I. INTRODUCTION

Little information is available regarding the relative merits of bits and suckers as planting material for the establishment of banana plantations. Opinions have often been expressed, but these are usually based on field observations in commercial plantings. Freeman (1938) discussed the use of butts, suckers and bits and considered that butts were to be preferred as planting material. On the other hand, Eastwood (1948) favoured suckers, and according to Malan (1949) this was the principal planting material used in South Africa in 1949. Mitchell

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(1950), Wills (1951) and Wills and Berrill (1953), however, considered bits to be superior. The results of field trials reported by the Jamaican Department of Agriculture (Anon. 1953) suggest that there is little difference between suckers and bits insofar as effects on time of maturity and yield of fruit are concerned. These trials were carried out on the Lacatan variety, which is not grown commercially in Australia, and the suckers were larger than those generally used here for the propagation of the Cavendish variety. The bit planting material was also of a different type.

As the type of planting material used to establish the crop may be important in commercial practice, a trial was laid down at the Maroochy Experiment Station, 70 miles north of Brisbane, to determine the performance of a range of sizes of bit and sucker planting material.

II. EXPERIMENTAL PROCEDURE

(a) Treatments and Layout

Bits 1 lb, 2 lb, 3 lb, 4 lb, 5 lb and 6 lb in weight were used. Except for the largest size, these bits were cut from corms of plants which had either just bunched or were close to bunching, and trimmed to a single outermost bud on the upper surface of the corm (the so-called "pink" eye) according to the method described by Wills and Berrill (1953). On account of their size, 6 lb bits were necessarily cut from corms of plants which had either bunched some time previously or from which the bunch had actually been harvested.

Suckers used were 10 in., 12 in., 14 in., 16 in., 18 in. and 20 in. in maximum corm circumference. They were selected for vigour, and had pseudostems tapering to spear points and carrying narrow sword leaves.

The experiment was laid out as a randomized block with five replications of 12 treatments and four plant plots; there were guard rows between blocks but not between plots in the individual blocks.

(b) Cultural Data

The Cavendish variety was used in the trial. The experimental area was planted on December 11, 1953, with a spacing of 9 ft × 9 ft between plants. Rows were established on the approximate contour, with inter-row surface drains. The Ducasses variety was close-planted on the northern and eastern boundaries as a windbreak.

The original soil pH was 5·1. Lime was applied at the rate of 1½ tons to the acre eight weeks before planting. According to the soil buffer curve this should have raised the pH to 5·5.

Standard fertilizer schedules were used, an 8:12:8 complete mixture being applied at the rate of 1½ lb per plant at shoot emergence, followed by two applications of the same mixture six weeks apart at the rate of 2 lb per plant. Bunches were propped as a protection against wind damage.

Suckers were removed as soon as they appeared above ground in order to minimize any effect of offshoot "parasitism" on bunch development in the plant crop from which yield data were to be recorded.

Weather conditions during the growing period were somewhat variable. The plants made excellent growth until early February 1954, but cyclonic winds about the middle of the month caused some leaf damage. Root injury was negligible, however, and normal growth was resumed soon after the temporary setback. In July of the same year, a second cyclone caused extensive leaf and root damage. Plant recovery was slow and growth did not return to normal until November 1954, when bunching was already in progress. Bunches were thrown between October 1954 and February 1955, but datum bunches were restricted to the December–February period. Harvesting commenced in January 1955 and was completed in July of the same year, all datum bunches being cut from April to June.

(c) Records

Growth data were recorded from all plants at monthly intervals up to the time of bunching. Times of sucker emergence were noted until two months after each bunch was harvested in order to determine the total sucker potential of the plant. All bunches were weighed at the time of harvest and the number of hands in the bunch and the number of fingers in each hand were counted. In addition, the distribution of fingers among the various market size grades was recorded.

III. RESULTS

(a) Plant Emergence

Planting was carried out on December 11, 1953, under favourable conditions and a good strike was obtained. Misses are recorded in Table 1.

TABLE 1

PERCENTAGE OF PLANTING MATERIAL FAILING TO SHOOT

Treatment No.	1	2	3	4	5	6	7	8	9	10	11	12
	Bits (lb)						Suckers (in. girth)					
	1	2	3	4	5	6	10	12	14	16	18	20
Misses (%)	5	–	10	5	–	30	15	5	10	–	–	–
	Mean 8·3%						Mean 5·0%					

With the exception of the 6 lb bits, differences in strike were of no importance. Bits of this size, however, could only be obtained from plants which had already bunched for a considerable period (in some cases the bunch had actually been harvested), and it is possible that nutrient reserves in the corm were low when the bits were cut. Further work is planned to elucidate this point.

Examination of the unshot 6 lb bits some two months after planting indicated that little or no primary root development had occurred and the eye showed no signs of enlargement. Rotting appeared to be negligible.

(b) Time of Emergence

The recorded data for periods from planting to shoot emergence are presented in Table 2.

TABLE 2

PERIOD FROM PLANTING TO SHOOT EMERGENCE (DAYS)

Treatment No.	1	2	3	4	5	6	7	8	9	10	11	12
	Bits (lb)						Suckers (in. girth)					
	1	2	3	4	5	6	10	12	14	16	18	20
No. of days (Mean) ..	27·3	24·9	33·6	27·5	27·8	30·4	28·7	21·7	21·7	23·6	20·8	21·4

Significant differences (1%)—Treatment No. 1>>11 ; 3>>2, 8, 9, 10, 11, 12 ; 5>>11, 12 ; 6>>8, 9, 11, 12 ; 7>>8, 11, 12.

Significant differences (1%)—Bits>>Suckers.

Significant differences (5%)—Regression co-efficient for suckers (linear) = — 1·08.

Bits required a significantly longer period to emerge after planting than did suckers. With the exception of those weighing 3 lb, bit size had no apparent effect on the period from planting to shoot emergence.

In suckers, 10 in. girth planting material required a much longer period to emerge than the 12–20 in. sizes. Small suckers are presumably still drawing nutrients from the parent plants when collected and the apparent setback which they suffer at planting may indicate inadequate food reserves in their corms. Since there were no differences in the times taken for the suckers ranging from 12 in. to 20 in. in girth to emerge, there appears to be some justification for regarding a 12 in. sucker as the minimum size for commercial plantings.

The regression co-efficient for suckers is significant only at the 5 per cent. level but the calculated relationship suggests that in general the period from planting to shoot emergence is slightly reduced when the larger sizes are used. No such relationship exists in the case of bits.

(c) Planting to Bunching

All datum bunches were thrown under good growing conditions over a period of six weeks from December 1954 to February 1955 and the rate of leaf

development was constant in all treatments. It therefore seems valid to use the recorded period from planting to bunching as an indication of the rate of plant development. The data are summarized in Table 3.

TABLE 3

PERIOD FROM PLANTING TO BUNCHING (DAYS)

Treatment No.	1	2	3	4	5	6	7	8	9	10	11	12
—	Bits (lb)						Suckers (in. girth)					
	1	2	3	4	5	6	10	12	14	16	18	20
No. of days (Mean) ..	399	387	396	386	380	372	418	394	396	386	366	354

Significant differences (1%)—Treatment No. 1>>6, 11, 12; 2, 4, 5, 10>>12; 3, 8, 9>>11, 12; 7>>2, 4, 5, 6, 10, 11, 12.

Significant differences (1%)—Regression co-efficient for bits (linear) = −4·89.

Regression co-efficient for suckers (linear) = −11·84.

It is evident from the regression co-efficients that for each 1 lb increase in weight of the bits used as planting material, the period from planting to bunching was reduced by some five days. Similarly, in the case of suckers, a 2 in. increment in the girth of the planting material reduced the period from planting to bunch emergence by some 12 days.

There is an obvious tendency for plants grown from large bits to throw their bunches early. The apparent discrepancy in the 3 lb bit data is due to the long period recorded between planting and shoot emergence. It would appear that the critical minimum weight for this type of planting material lies between 1 lb and 2 lb if maximum growth rate in the resulting plant is to be achieved.

The effect of size of planting material is more marked in the sucker than in the bit series of treatments. Plants grown from very small suckers (10 in. girth) were slow to throw their bunches, and conversely very large suckers (18–20 in. girth) passed through the vegetative phase quickly.

The average period from planting to bunching was almost 13 months in both bit and sucker planting material.

(d) Bunching to Harvesting

Periods from bunching to harvesting are recorded in Table 4.

TABLE 4

PERIOD FROM BUNCHING TO HARVESTING (DAYS)

Treatment No.	1	2	3	3	4	6	7	8	9	10	11	12
—	Bits (lb)						Suckers (in. girth)					
	1	2	3	4	5	6	10	12	14	16	18	20
No. of days (mean) ..	114	113	121	120	105	104	125	118	112	110	103	102

Significant differences (1%)—Treatment No. 3>>5, 6, 11, 12; 4, 8>>11, 12; 7>>5, 6, 10, 11, 12.

Significant differences (5%)—Regression co-efficient for bits (linear) = −2·21.

Significant differences (1%)—Regression co-efficient for suckers (linear) = −4·67

Bunch development was more rapid in plants grown from 5 lb and 6 lb bits than in those grown from bits weighing from 1 lb to 4 lb. As all bunches matured under similar climatic conditions, it appears that the length of the period from bunching to harvesting, like the period from planting to bunching, may be linked in some way with the nutrient reserves available in the bit at the time of planting.

In the sucker series of plants, the rate of bunch development shows a close correlation with size of planting material, bunches on plants grown from 10 in. suckers requiring 23 days longer to fill than bunches on plants grown from 20 in. suckers. Each 2 in. increase in sucker size brought the harvest forward by about five days.

Bit size had less influence than sucker size on rate of bunch development in the types of planting material used. This probably explains the greater uniformity in bunch harvesting in the several plots established from bits as compared with those established from suckers.

(e) Plant Height and Girth

Height was measured as the length of the pseudostem from ground level to the throat of the plant where the bunch stem first becomes visible. Plant girth was construed as the maximum circumference of the pseudostem and was read about 1 in. above ground level. Data for the several treatments are summarized in Table 5.

TABLE 5

PLANT HEIGHT AND PLANT GIRTH

Treatment No.	1	2	3	4	5	6	7	8	9	10	11	12
	Bits (lb)						Suckers (in. girth)					
	1	2	3	4	5	6	10	12	14	16	18	20
Height (in.)	65·4	65·5	63·6	66·3	67·3	67·7	60·9	64·4	61·6	62·8	63·0	59·7
Girth (in.)	27·7	27·8	26·6	27·6	27·8	27·9	26·0	27·1	26·2	26·2	26·0	25·2

Significant differences (1%) Height—Treatment No. 2, 4, 6>>12 ; 5>>7, 12.
Significant differences (1%)—Bits >>Suckers, for unweighted average heights.
Significant differences (1%)—Girth—Treatment No. 1, 2, 4, 5, 6>>12.
Significant differences (1%)—Bits>>Suckers, for unweighted average girth.

Plants grown from bits were taller than those grown from suckers, the mean difference of 3·9 in. being highly significant. Plants grown from bits were very uniform when compared with those grown from suckers. In the latter, a significant difference at the 5 per cent. level was recorded between Treatments 8 and 12, but the difference (4·7 in.) would be of no commercial importance.

There were no significant differences in girth between the plants grown from bits of various weights and those grown from suckers of various sizes. Mean girth measurement in bit plants, however, was significantly greater than that in sucker plants, the difference being 1·5 in.

Size of planting material, as opposed to type, had no apparent effect on either plant height or girth. It is, however, interesting to note that the height : girth ratio (2·3 : 1) was constant irrespective of the size or type of planting material used. This would suggest that there is probably always a definite ratio between height and girth in the Cavendish variety, but whether the value of 2·3 : 1 is constant under all environmental conditions has yet to be proved. Summerville (1944) obtained ratios ranging from 1·7 : 1 with small plants up to 2·0 : 1 with large plants, but these were all in the vegetative condition. In view of the progressive increase in the ratio with increasing plant size, it is very probable that a value approaching 2·3 might have been obtained if these plants had been measured at the time of bunching.

(f) Number of Leaves

The number of leaves recorded in this experiment included both juvenile (sword) leaves and those with normal adult characters.

The counts are summarized in Table 6.

TABLE 6

NUMBER OF LEAVES

Treatment No.	1	2	3	4	5	6	7	8	9	10	11	12
—	Bits (lb)						Suckers (in. girth)					
	1	2	3	4	5	6	10	12	14	16	18	20
No. of leaves	42·1	40·7	40·5	39·7	39·3	38·3	44·4	43·1	42·2	41·8	39·0	36·8

Significant differences (1%)—Treatment No. 1, 9>>4, 5, 6, 11, 12; 2, 3, 4, 5, 11>>12; 7>>2, 3, 4, 5, 6, 10, 11, 12; 8>>2, 3, 4, 5, 6, 11, 12; 10>>5, 6, 11, 12.

Significant differences (1%)—Regression co-efficient for bit size (linear) = −0·68.

Regression co-efficient for sucker size (linear) = −1·45.

In both bit and sucker series of plants, there was an inverse relationship between number of leaves and size of planting material: the larger the planting material, the smaller the number of leaves produced by the plant. In the bit series of plants, the difference between maximum and minimum numbers of leaves was 4; in the sucker series it was 7. Thus, for every 1 lb increase above the minimum weight (1 lb) of the bits used, leaf number was reduced by 0·68. Similarly, for every 2 in. increase in sucker girth above the minimum used (10 in.), leaf number was reduced by 1·45.

Variations in leaf number would appear to be correlated with the vigour of the plant, as trends in the data for leaf numbers and periods from planting to bunching are much the same. Summerville (1944) showed that, provided the

supply of plant nutrients is not the limiting factor, the rate of leaf production is mainly dependent on the prevailing temperature and soil moisture conditions. A plant which required a longer period to reach the bunching stage would therefore be expected to produce a greater number of leaves. The present results appear to confirm this. The recorded differences in leaf number are derived primarily from adult leaves; the number of juvenile leaves was more or less constant (an average of 4 for bits and 3·5 for suckers). Leaf production in plants adequately supplied with nutrients (as in this trial) averaged 4 sword-leaves and 36–37 adult leaves.

The absence of any correlation between girth of the plant and leaf number suggests that the growth rate of the plant may also be important in girth development. In a vigorously growing plant the external leaf bases are probably forced outwards by the expansion of the pseudostem to a greater extent than in a plant which is growing less rapidly. This would obviously increase the girth measurement in the more vigorous plant. It should also be noted that as plant heights were not significantly different and numbers of leaves were, the greater the number of leaves the less the distance to which they were extruded. This distance is therefore a useful criterion of plant vigour.

(g) Number of Suckers

All suckers were removed as soon as they appeared above the ground in order to eliminate possible effects of offshoot parasitism on bunch size in the parent plant. Records are therefore available of the number of suckers produced and their dates of emergence. Data on the total number of suckers produced are summarized in Table 7.

TABLE 7

NUMBER OF SUCKERS

Treatment No.	1	2	3	4	5	6	7	8	9	10	11	12
	Bits (lb)						Suckers (in. girth)					
—	1	2	3	4	5	6	10	12	14	16	18	20
No. of suckers	18·0	17·7	18·3	16·8	16·6	16·6	17·6	17·0	17·1	17·6	16·2	19·5

Significant differences—Nil.

The type and size of planting material had no effect on the total number of suckers produced. This would be expected in the case of bits, for each plant is the product of a single eye which develops into a new corm. These should logically have similar sucker potentials. The uniformity of sucker production in plants grown from suckers, however, would suggest that these must have also formed new corms after planting; secondary corm formation in suckers is common in southern Queensland. Additional support for this suggestion comes from a consideration of the number of leaves produced by the plants grown

from 20 in. suckers and the period from planting to bunching. From the data presented by Summerville (1944) it is fairly certain that bunch initiation had already commenced in these large suckers before they were planted. If development had continued from the original growing point, only a relatively small number of leaves would have been produced before the bunch was thrown. Actually, however, these plants did not bunch until 354 days after planting (see Table 3) and produced 36·8 leaves (see Table 6), so it would appear that a new corm was formed.

The removal of suckers as they appeared would have the effect of stimulating development in the remaining sucker buds, and it is assumed that most, although probably not all, of the buds on the exposed sides of each corm were forced into growth. Such buds are, of course, quite distinct from buds situated between leaf bases on the upper surface of the corm which normally remain dormant under field conditions. The latter are used in preparing bits for planting.

The total number of suckers produced by each plant was approximately 17. Of these, an average of 13 appeared above ground prior to bunching, 2 between bunching and harvesting and 2 after the bunch had been cut. It follows, therefore, that where practicable the follower for the ratoon crop should always be set before the bunch is thrown by the parent plant. If setting is delayed beyond this stage, the chance of a suitable follower being available in the right position becomes increasingly remote and the suckers themselves may be lacking in vigour.

(h) Number of Hands and Bunch Weight

All bunches were harvested in the mature-green stage, the fruit being weighed (after removal from the stalk) and the numbers of hands and the numbers of fingers per hand recorded. Data for bunch size and net fruit weight are summarized in Table 8.

TABLE 8

NUMBER OF HANDS AND NET BUNCH WEIGHT

Treatment No.	1	2	3	4	5	6	7	8	9	10	11	12
	Bits (lb)						Suckers (in. girth)					
	1	2	3	4	5	6	10	12	14	16	18	20
No. of hands/bunch ..	10·1	9·9	9·7	9·9	10·1	9·6	9·4	10·0	9·3	9·4	9·0	8·0
Weight of fruit/bunch (lb)	54·8	53·8	51·9	52·6	53·3	51·8	45·6	54·3	46·7	47·0	44·2	38·5

Significant differences (1%)—Hands per bunch—Treatment No. 1 to 11>>12; 1, 5>>11.
Bits>>Suckers.
Regression co-efficient for sucker size (linear) = −0·287.

Significant differences (1%)—Weight of fruit—Treatment No. 1, 2, 3, 4, 5, 6, 8>>12.
Bits>>Suckers.

Significant differences (5%)—Weight of fruit—Regression co-efficient for sucker-size (linear) = −1·885.

There were no significant differences in the number of hands per bunch in plants grown from bits, the average being 9·9. The bit series of plants, however, produced a significantly greater average number of hands than the sucker series, the mean difference being 0·7.

The number of hands per bunch was similar in plants grown from suckers with girths of 10 in., 12 in., 14 in. and 16 in. but declined slightly in plants grown from 18 in. suckers, and even more in those produced by the 20 in. size.

The regression co-efficient for plants grown from suckers, unlike that for those grown from bits, was significant in terms of hand number: for every increase of 2 in. in sucker girth, the number of hands decreases by 0·287.

Bunch weights for the several treatments show the same trends as the number of hands per bunch. This is not surprising, as both would be controlled to a large extent by the nutritional status of the plant. The average weight of fruit per bunch in plants grown from bits was 53 lb, with negligible differences between treatments. The corresponding mean value in plants grown from suckers was 46 lb, which was significantly lower than in the bit series.

It would appear that the size of bits is of little importance in selecting planting material, although in commercial practice the smallest size used (1 lb) would be considered unsatisfactory owing to the risk of a faulty strike if stress conditions occurred following planting. Large bits, on the other hand, are more difficult to transport, and larger butts are required for their preparation. The optimum weight, therefore, would probably be 2-4 lb.

The greater bunch size in plants grown from bits as compared with plants grown from suckers makes them a first choice as planting material. Where bits are not available, 12 in. suckers seem preferable to both larger and smaller sizes. They are easily removed from the parent plant, and they are generally in ample supply and fairly light to transport. Furthermore, the bunch size and fruit weight produced by the plants grown from them show a tendency (which does not quite reach significance) to be greater than those of plants grown from larger material.

(i) Total Number and Weight of Fingers

Although bunch weight is the usual criterion of productivity, bunch values are influenced to a considerable extent by the number and size of fingers because certain counts sell at a premium. Finger counts and weights are summarized in Table 9.

TABLE 9

NUMBER OF FINGERS AND WEIGHT PER FINGER

Treatment No.	1	2	3	4	5	6	7	8	9	10	11	12
	Bits (lb)						Suckers (in. girth)					
	1	2	3	4	5	6	10	12	14	16	18	20
No. of fingers/bunch ..	169	164	157	158	167	160	151	162	149	152	140	120
Weight of finger (oz)	5·18	5·22	5·28	5·31	5·07	5·17	4·71	5·37	4·99	4·94	4·95	5·06

Significant differences (1%)—Number of Fingers—Treatment No. 1 to 10>>12 ; 1, 2, 5>>11.

Bits>>Suckers

Regression co-efficient for sucker size (linear) = −6·21

Significant differences (5%)—Regression co-efficient for bit size (linear) = −1·07.

Significant differences (1%)—Weight/Finger—Nil.

As with number of hands and net weight of fruit, size of bit planting material had no influence on the number of fingers per bunch. In the sucker series, the number of fingers followed the same trend as the net bunch weight, the lowest figure being recorded for the largest planting material. This reduction in finger number for the 20 in. suckers is more than can be accounted for by the lower number of hands, and it is evident that in this treatment the finger number was reduced over several if not all hands. As a group, plants derived from bits produced a significantly greater number of fingers per bunch than those from suckers, the difference being 17. The regression co-efficient for sucker size indicates that for each increase of 2 in. in sucker girth, the number of fingers per bunch decreases by 6·21. The regression co-efficient for bit size reached significance only at the 5 per cent. level, and in any case the figure is negligible.

Finger weight was apparently unaffected by the type or size of planting material used. Fruit filling is normally controlled largely by soil moisture and plant nutrients, and in this trial neither of these was a limiting factor. It is probable, however, that any restriction imposed by deficiency of plant nutrients would have resulted in a reduction in finger number in the first instance rather than affecting the average finger weight.

IV. CONCLUSIONS

(1) Plants grown from bits took a significantly longer time to emerge than those from suckers, the difference being six days. Bit plants, irrespective of size, appeared above ground at much the same time but the larger suckers emerged more quickly than the smallest size.

(2) Size of bit planting material had no appreciable effect on the period from planting to flowering, which was approximately 13 months, but the smallest suckers required a longer and the largest a shorter period. Plants from bits weighing 5 or 6 lb matured their bunches about two weeks earlier than plants from smaller bit sizes (1–4 lb). The period from flowering to maturity showed a linear regression in plants grown from suckers: the larger the sucker, the more quickly the bunch matured its fruit. The maximum difference between types of sucker planting material was 23 days.

(3) Plants grown from bits were more uniform in height, were taller (by 4 in.) and had a greater girth (by 1½ in.) than plants grown from suckers. The average height of plants derived from bits was 66 in. Plant height was constantly equal to maximum stem girth × 2·3 in this trial. The average total number of leaves produced (juvenile plus adult) ranged from 40·1 for bits to 41·2 for suckers, and varied with size of planting material in both bit and sucker series of plants. Increasing size of planting material was associated with decreasing number of leaves.

(4) Neither size nor type of planting material had any effect on the total number of suckers produced. On the average, a plant produced 13 suckers before it bunched and 4 thereafter.

(5) Size of planting material, except in the 20 in. suckers, had no significant influence on the number of hands per bunch or the number of fingers per bunch, but sucker planting material invariably produced bunches with a lower number of hands (mean 9·2) than bit planting material (mean 9·9). The average number of fingers per bunch in the bit series was 163, this being 11·6 per cent. higher than the figure for suckers. Hand numbers per bunch in plants grown from 20 in. suckers were low, suggesting that these plants were lacking in vigour.

(6) The average net fruit weight per bunch from bit planting material was 53 lb, which was 15·2 per cent. greater than that from sucker planting material. Net fruit weight was not significantly affected by size of bit planting material, but showed a linear regression in plants grown from suckers, the larger sizes producing the smaller bunches. Fruit filling was apparently not affected by size or type of planting material used.

(7) Practical considerations would probably restrict bit weight to material within the 2–4 lb range and suckers to material about 12 in. in maximum girth.

V. ACKNOWLEDGEMENT

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INSECTICIDAL CONTROL OF SORGHUM MIDGE, *CONTARINIA SORGHICOLA* (Coq.)

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SUMMARY

On the Darling Downs and in the Callide Valley during 1951-1956, 8 field trials were carried out using insecticides against sorghum midge, *Contarinia sorghicola* (Coq.).

Trial results, and consequent commercial practice, demonstrate that spraying at flowering with DDT (1 lb/ac in not less than 15 gal) in well-grown crops is economically sound when midge populations exceed 6 females per head. When swarm populations are present the save is 50–60 per cent.

I. INTRODUCTION

Contarinia sorghicola (Coq.), although first recorded in Queensland in 1894 (Tryon), was not of economic importance until the introduction of dwarf sorghum varieties resulted in a considerable expansion in the acreage sown for grain production. Cultural controls were discussed by Atherton (1941), Sloan (1945) and Officers of the Department of Agriculture and Stock (1951), and by Passlow (1955), who stated that the use of DDT in a well-grown crop when pest populations are high may result in a 50–60 per cent. save. The trials on which this recommendation was based, and later trials, are recorded in this paper.

II. MATERIALS

The following insecticides were used:—

BHC.—A dispersible china clay powder containing 6·5 per cent. gamma isomer.

An emulsifiable preparation containing 6·5 per cent. gamma isomer.

Chlordane.—A kaolin dust containing 2 per cent. active ingredient.

DDD.—An emulsion concentrate containing 20 per cent. w/v $\rho.\rho'$ isomer (30 per cent. w/v technical).

DDT.—A kaolin dust containing 2 per cent. $\rho.\rho'$ isomer.

An emulsion concentrate containing 25 per cent. w/v $\rho.\rho'$ isomer.

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Dieldrin.—An emulsifiable preparation containing 15 per cent. w/v active ingredient.

Endrin.—An emulsifiable preparation containing 20 per cent. w/v active ingredient.

Parathion.—An emulsifiable preparation containing 25 per cent. w/v active ingredient.

Toxaphene.—A kaolin dust containing 2 per cent. active ingredient.

III. METHODS

Trial 1 was set out as 9 × 3 randomized block with plot size of 11 ft × 4 ft; Trials 2–5 were 5 × 5 latin squares with plots of 1/80 ac; and Trials 6–8 were randomized blocks of 1/100 ac. Pest populations were assessed by counting the females in random samples of at least 10 heads per plot. Degrees of flowering were estimated from counts of not less than 50 stems per plot (except Trial 1).

In Trial 1, insecticides were applied with a hand atomizer and a duster to give thorough coverage of the heads and of "throats" from which heads had not yet emerged. In the other trials a knapsack was used: application rates per acre were 40 gal in Trials 2–5, 100 gal in Trials 6 and 7, and 50 gal in Trial 8.

Trials 2–5 were designed to investigate efficacies of DDT treatments when used as one or two applications either early or late in the flowering period. In Trials 6–8 spraying was carried out as indicated by pest population assessments. Further relevant details, including insecticide strengths expressed as active ingredients, are given with the results.

Harvests were complete except in Trial 2, where every fifth head only was taken. Stand counts were made in all plots, and in those trials where the regression of yield on number of heads was positive adjusted yields based on an equal number of heads per plot were calculated. Yields are expressed in the economic unit of bushels per acre.

IV. RESULTS

(a) Trial 1—Screening, 1951

Insecticides were applied to a crop of the variety Martin at Mt. Tyson, Darling Downs, on March 3, when 75 per cent. of stems had produced heads and 60 per cent. of the crop was at or past anthesis. A midge population of 50–60 females per head was present. The trial was harvested on May 7, and results are given in Table 1.

TABLE 1

TRIAL 1: HEADS PER PLOT AND YIELDS

Treatment	Mean Number of Heads per Plot	Yield (bus./ac)	
		Observed	Adjusted
BHC 0·1% emulsifiable spray	47·0	27·9	28·3
DDT 2·0% dust	57·7	19·3	16·3
Chlordane 2·0% dust ..	53·0	18·1	16·6
Toxaphene 2·0% dust ..	50·0	17·7	17·1
DDT 0·1% spray ..	41·3	16·3	18·6
Parathion 0·015% spray	48·3	13·5	13·5
Checks—mean of three ..	(45·7)	(11·8)	(12·7)
Necessary differences for significance .. 5%	20·3	9·8	7·7
Necessary differences for significance .. 1%	27·6	13·5	10·5

The excessive BHC application resulted in practically complete control, and provides a base for estimating percentage save.

(b) Trials 2 to 5—DDT Levels, 1951

Immediately prior to sprayings flowering was assessed, and relevant data are given in Table 2.

TABLE 2

TRIALS 2–5: FLOWERING

Trial	Stems with Heads Emerged (%)		Stems with Heads At or Past Anthesis (%)	
	At 1st Applic.	At 2nd Applic.	At 1st Applic.	At 2nd Applic.
2	44·75	67·75	18·0	45·5
3	75·5	86·0	48·5	76·5
4	91·0	95·5	62·0	91·5
5	61·5	100·0	24·5	87·0

Trials 2 and 3 were adjacent in a field of Martin at Mt. Tyson and sprays were applied on February 24 and 27 in Trial 2, and on February 28 and March 5 in Trial 3. Few midges were noted on February 21 but on February 24 an average of 6 females per head was recorded. The population increased steadily to a peak of more than 50 per head (a swarming population) on March 5, and decreased rapidly to 6 females per head on March 8.

Trial 4 was in a field of Alpha at Mt. Tyson and insecticide was applied on March 2 and 8. Pest population was low prior to March 1, when very high numbers were recorded: this high population was present until the bulk of flowering had occurred.

Treatments were applied in Trial 5, in Plainsman at Biddeston, Darling Downs, on March 8 and 15. Pest numbers were 2 females per head during the application period.

Trials 2 and 3 were harvested on May 8–10, Trial 4 on May 14, and Trial 5 on May 21: results are set out in Tables 3 and 4.

TABLE 3

TRIALS 2 AND 3 : YIELDS

Treatment	Trial 2		Trial 3	
	Mean Yield (oz/100 heads)	Yield (bus./ac)	No. of Heads per Plot	Yield (bus./ac)
DDT emulsion 1 lb/ac in two applications	51·2	22·6	557	23·20
DDT emulsion 1 lb/ac in one application	50·7	22·4	573	19·80
DDT emulsion ½ lb/ac in two applications	49·4	21·8	525	19·38
DDT emulsion ½ lb ac in one application	45·6	20·1	593	20·55
Check	24·2	10·7	565	12·08
Necessary differences for significance (1%)	20·2		No significant differences	5·68

TABLE 4

TRIALS 4 AND 5 : YIELDS

Treatment	Trial 4			Trial 5		
	No. of Heads per Plot	Yield (bus./ac)		No. of Heads per Plot	Yield (bus./ac)	
		Observed	Adjusted		Observed	Adjusted
DDT emulsion 1 lb/ac in two applications	623	25·4	27·1	363	19·5	18·4
DDT emulsion 1 lb/ac in one application	641	24·7	25·6	332	20·4	21·0
DDT emulsion ½ lb ac in two applications	673	23·6	23·0	332	19·7	20·3
DDT emulsion ½ lb ac in one application	695	24·3	22·7	341	17·9	17·9
Check	669	15·0	14·6	343	19·7	19·7
Necessary differences for significance 5%	60	3·1	1·5	No significant differences		
Necessary differences for significance 1%	84	4·4	2·1			

These results indicate that when pest populations are high, DDT application may double yields. In these trials, however, the best yields obtained were not more than 50–60 per cent. of those which would have been obtained in the absence of midges. One application was efficacious and within limits, as in Table 2, percentage flowering was not critical so far as timing was concerned during the period of high pest population.

A population of 2 females per head does not warrant spraying (Trial 5).

(c) Trials 6 to 8

Trial 6 was established at Bongeen, Darling Downs, in Martin which carried a population of 0–6 females per head on the treatment date; at no stage was the pest population severe. All insecticides were applied on March 22–23, 1954, when the bulk of the crop was flowering. A large number of plants, however, produced late tillers which did not flower until much later than the application date.

Trial 7 at Thangool, Callide Valley, was in a field of Caprock which carried a population of 6–20 females per head on treatment date, April 14, 1955. The bulk of the crop was at mid- to full-flowering when the insecticides were applied, but as in Trial 6 many later tillers were produced.

In Trial 8, situated in Alpha at Biloela, Callide Valley, sprays were applied on March 14, 1956, when most heads had completed flowering. Six to 8 females per head, however, were still active in the crop.

White oil was used as a wetting agent in Trials 7 and 8 at the rate of 1 gal per ac.

Trial 6 was harvested on May 12, Trial 7 on June 27, and Trial 8 on May 2: results are given in Tables 5–7.

TABLE 5

TRIAL 6 : YIELDS

Treatment	Yield (oz/100 heads)	Adjusted Yield (bus./ac)
DDT emulsion 1 lb/ac	116·8	31·22
BHC disp. powder 0·33 lb/ac	113·8	30·33
Endrin 0·5 lb/ac	112·2	29·11
BHC disp. powder 0·1 lb/ac	108·8	28·56
Endrin 0·25 lb/ac	107·8	29·00
Dieldrin 0·5 lb/ac	105·8	28·12
Dieldrin 0·25 lb/ac	104·7	27·62
BHC disp. powder 0·25 lb/ac	104·0	27·28
BHC emulsion 0·25 lb/ac	99·2	26·74
Checks—mean of three	97·3	25·93
Necessary differences for significance 5%	10·6	2·86
Necessary differences for significance 1%	14·1	3·81

TABLE 6

TRIAL 7 : YIELDS

Treatment	Yield		No. of Heads per Plot
	lb/plot	bus./ac	
BHC disp. powder 1 lb/ac	10·37	17·3	316·7
BHC disp. powder 0·7 lb/ac	9·96	16·6	345·0
BHC disp. powder 1 lb. ac plus White oil	9·83	16·4	312·3
DDT emulsion 1 lb/ac	9·21	15·4	309·0
BHC disp. powder 0·7 lb ac plus White oil	8·54	14·2	325·3
DDT emulsion 1 lb/ac plus White oil	8·44	14·1	305·0
DDT emulsion ½ lb/ac plus White oil	8·23	13·7	315·3
BHC disp. powder 0·3 lb/ac plus White oil	7·48	12·5	325·7
DDT emulsion ½ lb/ac	7·14	11·9	314·7
BHC disp. powder 0·3 lb/ac	6·02	10·0	313·7
Checks—mean of three	4·33	7·2	306·6
Necessary differences for significance among treatments 5%	2·56	4·27	No significant differences
Necessary differences for significance among treatments 1%	3·46	5·77	
Necessary differences for significance between checks and treatments 5%	2·09	3·48	
Necessary differences for significance between checks and treatments 1%	2·83	4·72	

TABLE 7

TRIAL 8 : YIELDS

Treatment	Yield (bus./ac)	
	Observed	Adjusted
DDT emulsion 1 lb/ac plus White oil	32·7	29·2
DDD emulsion 1 lb/ac	30·6	28·8
BHC disp. powder 0·3 lb/ac	30·4	28·4
BHC disp. powder 1 lb/ac plus White oil	27·9	29·9
DDT emulsion 1 lb/ac	26·3	26·2
BHC disp. powder 0·7 lb/ac	26·1	28·9
BHC disp. powder 1 lb/ac	25·2	24·3
BHC disp. powder 0·3 lb/ac plus White oil	25·2	26·1
DDD emulsion ½ lb/ac plus White oil	24·7	23·0
DDT emulsion ½ lb/ac plus White oil	23·7	22·5
DDD emulsion 1 lb/ac plus White oil	22·5	25·1
DDT emulsion ½ lb/ac	19·6	19·0
BHC disp. powder 0·7 lb/ac plus White oil	18·2	21·5
DDD emulsion ½ lb/ac	18·1	19·3
Checks—mean of three	22·5	22·2

No significant differences

V. DISCUSSION

Results from Trials 6–8 give further information on pest populations which warrant treatment and demonstrate that, as expected, the use of insecticides results in greater percentage saves when pest populations are high (compare Trials 2 and 3 with 6).

Spraying is of no economic value when and after major flowering is complete (Trial 8).

Commercial practice using not less than 15 gal per ac confirms trial results: spraying with DDT at 1 lb per ac is economically sound in well grown crops when midge populations exceed 6 females per head at flowering. Usually boom sprays mounted on single-wheel trucks of standard clearance are employed in field spraying; damage caused by the passage of such a vehicle carrying a 40 ft boom is estimated as not exceeding 2 per cent. of the crop, this loss being caused almost entirely by the wheels.

VI. ACKNOWLEDGEMENTS

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OBSERVATIONS ON SURVIVAL OF CATTLE TICK, *BOOPHILUS MICROPLUS* (Can.) IN NORTH QUEENSLAND

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SUMMARY

In a preliminary study of cattle tick survival near Townsville, female ticks were placed in guinea grass tussocks on 14 occasions between July 1956 and July 1957. Weekly observations were made on the development period of the eggs and on the survival of the larvae.

The longest survival period from the collection of the parent female ticks to the death of all larvae was 19 weeks. These ticks were put out in March. Egg development period varied from 3 weeks in summer to 10 weeks in winter.

In one series the female ticks were flooded for 24 hours and many of their eggs failed to hatch.

The relevance of the results to possible improvements in tick control in the Townsville area is discussed.

I. INTRODUCTION

There is a paucity of information on cattle tick survival in North Queensland pastures and this information is needed in formulating plans for improved tick control by pasture spelling (Wilkinson 1957) or strategic dipping (Norris 1957). This tick has become resistant to many acaricides, and control methods are often difficult and expensive (Wilkinson 1957). Snowball (1957) and Wilkinson and Wilson (1959) have described observations on tick survival in southern and central Queensland, discussed the methods used and reviewed the literature.

These observations were carried out at the Animal Health Station at Oonoonba, three miles south of Townsville. Recently, it became possible to initiate more intensive observations over a wider range of sites in the Ingham-Townsville-Charters Towers area, but as it may be several years before the results of the latter observations are published, it is considered desirable to record the results of the Oonoonba observations. Legg (1930) made some observations on larval survival in the same area, using laboratory-bred larvae, but his data refer chiefly to the maximum possible survival time and are not suitable for the purpose outlined above.

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II. METHODS

Engorged female ticks obtained from Animal Health Station cattle, or collected from stalled animals at Brisbane and transported by air to Townsville, were placed in gauze cylinders similar to those described by Snowball (1957). The cylinders were inserted vertically in holes made in the centres of guinea grass (*Panicum maximum* Jacq.) tussocks so that each cylinder was entirely surrounded by soil and grass tissue, except for the upper surface of the top cork. In this position the tops of the cylinders were somewhat above the soil level around the tussocks, so that the cylinder contents were in a moderately well drained situation and were sheltered from insolation and free air circulation. The tussocks chosen were 6 ft. or more apart.

In the first placement, 10 cylinders were put out, with 1–5 ticks per cylinder, but on the remaining occasions each cylinder contained three ticks. The number of cylinders put out on each occasion is shown in Figure 2. The ticks were inspected each week. When hatching was first seen the top cork was removed

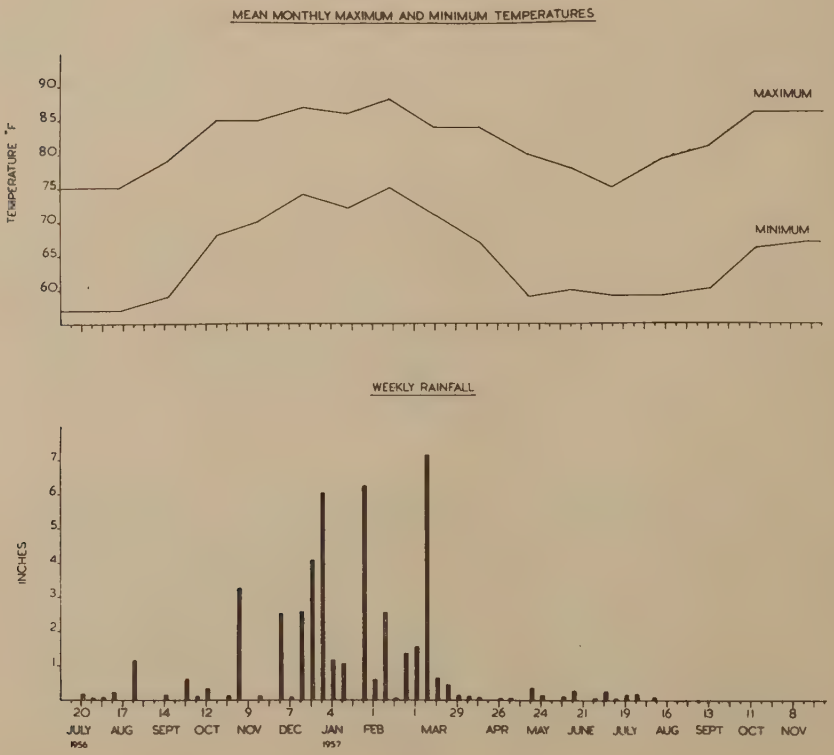

Fig. 1

Meteorological conditions during the observations, as recorded at Garbutt airfield, five miles from Oonoonba.

from the cylinder, allowing the larvae to escape. The observations continued for three weeks after larvae could no longer be found on the grass blades by careful examination. On April 5, in addition to the ticks put out in unshaded tussocks, a cylinder containing three ticks was put out under each of seven tussocks shaded by hessian screens (3 ft × 3 ft) suspended horizontally at a height of 4 ft.

Meteorological data (Figure 1) were taken from Garbutt (Townsville) airfield, five miles away.

III. RESULTS

The records for ticks on unshaded tussocks are summarized in Figure 2. The pre-hatch period and duration of larval survival of those larvae which survived longest out of each batch are shown, together with the mean of the periods recorded from all the cylinders in each batch.

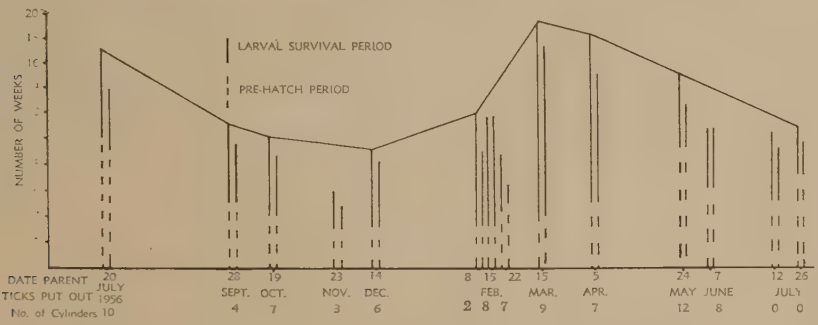

Fig. 2

Duration of survival of cattle tick larvae on grass at Oonoonba. The left-hand line of each pair refers to the longest surviving larvae of each batch, the right-hand line to the mean of the pre-hatch and survival periods recorded for all cylinders in each series.

The arbitrarily smoothed line joining the summits of the lines is intended as a provisional guide to pasture spelling periods in the district.

The eggs from ticks put out on February 22 were flooded for 24 hours, due to heavy rain in the week commencing March 8.

During the greater part of the year the non-parasitic survival was less than 17 weeks. The longest survival time was 19 weeks, but only a small percentage of these larvae survived longer than 17 weeks.

Heavy rain fell during the week beginning March 8, 1957, and most of the eggs under observation were covered with water for more than 24 hours. Many of these eggs failed to hatch. In another series the number of larvae on the grass plants was not markedly reduced, compared with an observation five days previously, although 6 in. of rain were recorded in the 24 hours preceding the second observation. The first hatch of larvae had occurred only one week before the first of these two observations, so it was possible that fresh larvae had hatched between these observations and replaced those dislodged by rain.

The longest living larvae on the shaded tussocks survived a week longer than those on the unshaded tussocks. Since they hatched a week later, the period from first observed hatch to death of all larvae was the same as on unshaded tussocks. The mean of the survival periods recorded for the larvae from the seven shaded cylinders was 18 weeks, that is, two weeks longer than the mean for the unshaded ticks.

IV. DISCUSSION

Observations on ticks in relatively small plots do not give as much detailed information on the rate of decline of the larval population as is obtained by the more laborious procedure of pasture sampling, and it is advisable to confirm the small-plot results by admitting cattle to larger paddocks at suitable intervals after destocking and examining the cattle for tick infestation. However, by inference from earlier work (Wilkinson 1957), it is considered probable that tick populations in paddocks near Townsville would be reduced to a low level if cattle were removed for periods corresponding to the longest survivals, for the particular time of the year, observed on the Oonoonba plot. Until data are available from more frequent tick exposures, these periods are probably best determined from the arbitrarily smoothed line (Figure 2) running through the upper extremities of the vertical columns. The average survival figures may not give a true indication, because the shortest periods are probably much affected by chance factors, but they illustrate the variability of the results.

The shaded series was included at a time of year when survival was likely to be long, because it appeared that the duration of the stages was longer where there was intermittent shade from trees bordering the plot. The observations on the failure of heavy rainfall to reduce larval numbers are of interest, since Wilkinson and Wilson (1959) discussed the possible importance of rain and wind in reducing tick survival. In this instance, apart from the possibility of fresh larvae hatching, the original larvae may have been washed off and have re-ascended, and this re-ascension would deplete their limited energy reserves. Observations during heavy rainfall and rain-with-wind would be of interest.

In contrast to the results in southern Queensland (Snowball 1957), development of the eggs can be completed at any time of the year at Oonoonba. Pre-hatch periods tend to be shorter than those observed by Wilkinson and Wilson (1959) in central Queensland. These authors have pointed out that longer larval survival can be expected if observations are made on larvae arising from a massed placement of several ticks, compared with observations on the progeny of single ticks. In this respect the present study is intermediate between the individual ticks used in central Queensland and the work in southern Queensland in which a number of the progeny of 20 ticks was allowed to ascend grass over a small area (18 in. × 12 in.).

The present results support the view that the pasture spelling periods proposed earlier (Anon. 1955) should be adequate for the Townsville district, but as pointed out in that publication, these are only some of the possible ways in which advantage can be taken of the limited survival of the non-parasitic stages of this tick. One important factor influencing the choice of the pasture spelling regimen is the rate at which tick populations can be expected to increase when lightly infested cattle enter an uninfested paddock. This rate of increase will be influenced by many things, for instance, the vegetation of the area and the degree of tick-resistance of the cattle (Wilkinson 1955).

Some remarks on the foreseeable role of pasture spelling in North Queensland seem appropriate. Harbour (1957), apparently referring to Caribbean conditions, expressed doubt on the practicability of the method. He advocated dipping at intervals as short as seven days. On many North Queensland stations, owing to the large areas and large numbers of cattle for each stockman employed, it is not possible to muster most of the cattle even every three weeks, as for "strategic dipping". Seddon (1951) quoted an estimate that about 2½ million Queensland cattle are dipped fewer than five times a year. On some properties pasture spelling has proved practicable and improved tick control, with infrequent musterings, has been reported. On the other hand, "strategic dippings" may be preferred for dairy herds or smaller herds of beef cattle.

The effects of pasture spelling on the growth and survival of the more useful fodder plants has to be considered. Few publications on this aspect of tropical pasture management have come to notice. It has been reported by Nunn and Suijendorp (1954) and Nunn (1958) that deferred grazing for two or three months resulted in extensive pasture regeneration in tropical Western Australia. It will probably be many years before the advantages and disadvantages of pasture spelling can be adequately assessed, but it should be considered as a method of tick control, particularly where the time of survival of the non-parasitic stages is short.

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IRON SUPPLEMENTATION IN PIGLET ANAEMIA

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SUMMARY

A total of 111 Large White/Berkshire cross piglets in 14 litters was used for iron supplementation studies. Of 87 piglets supplemented with iron, 30 received *Ferri et Ammonii Citrate* orally, and 57 iron-dextran intramuscularly. Twenty-four untreated piglets were kept as controls.

The blood haemoglobin levels fell within four days after birth by 30 per cent. or more, and reached the lowest level usually by the second or third week.

Symptoms of anaemia were diarrhoea, paleness, listlessness and respiratory distress.

Oral therapy with *Ferri et Ammonii Citrate* was not as effective as parenteral administration of iron-dextran in restoring the haemoglobin levels.

The ease of administration, rapidity of response and the need for only one treatment favour the use of iron-dextran in the prevention and treatment of piglet anaemia.

Because sow's milk is a poor source of nutritional iron, it is important that piglets should be introduced at the earliest age possible to iron-supplemented creep feeding.

I. INTRODUCTION

Since the first description of piglet anaemia by McGowan and Crichton (1923), considerable attention has been given to this condition. The present knowledge of the aetiology, clinical symptoms, pathological manifestations, haematological changes and treatment has been reviewed by Seamer (1956).

Briefly, the disease has been described as microcytic hypochromic anaemia which affects mainly rapidly growing piglets during the first few weeks of life. Clinical signs of the disease are abnormal pallor, oedema of the eyelids, listlessness, reluctance to move, respiratory embarrassment at the slightest exertion, and diarrhoea. Death may occur suddenly from anaemia when the haemoglobin levels fall below the critical value, or from intercurrent respiratory infection.

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The pathological changes are principally a swollen enlarged liver with centrilobular fatty degeneration and necrosis, enlargement and dilatation of the heart (Shanks 1953), hydropericardium, pericarditis and haemopericardium (McGowan and Crichton 1923, 1924; McGowan 1924; and Doyle, Mathews, and Whiting 1928).

Most workers agree that piglet anaemia is essentially a nutritional iron deficiency, mainly because of the beneficial results obtained with various iron preparations in its treatment and prophylaxis. On the other hand, Howie, Biggar, Thomson, and Cook (1949) encountered anaemia in piglets given ample doses of iron during studies on pig housing, especially in those farrowed in cold, damp and draughty indoor pens with cold uninsulated floors. Brooksbank (1954) suggested copper deficiency as one of the causes. This is to some extent supported by the work of Gubler, Lahey, Chase, Cartwright, and Wintrobe (1952), who found that copper deficiency causes abnormalities in the iron metabolism of swine. Köhler (1956 *a*, 1956 *b*, 1957), on the basis of a definite shift in the serum albumin and gamma globulin ratio and the presence of sufficient iron in anaemic piglets, regarded deficiency of essential amino-acids as a more important factor than iron deficiency in the genesis of this disease.

In the treatment of piglet anaemia, various iron preparations, usually administered by the oral route, have been advocated. In his review, Seamer (1956) listed a number of preparations which have been used, viz. ferric oxide (to the sow), dialysed iron, ferric chloride, ferric citrate, ferric sulphate, iron pyrophosphate, reduced iron and an iron-dextran complex. Of these preparations, iron-dextran is the most recent to come into use, following initial experiments by Barber, Braude, and Mitchell (1955 *a*), Brownlie (1955), and later by other workers (McDonald, Dunlop, and Bates 1955; Birk-Sorenson and Christensen 1956; Christensen 1956; Behrens 1957; Dale and MacKay 1958; and Gwatkin and L'Ecuyer 1959). It is administered parenterally and has the advantage that the iron is readily absorbed and utilized.

At the time when treatment of our experimental piglets became imperative, iron-dextran was not available. *Ferri et Ammonii Citrate* was used in the belief that it was more readily absorbed than the other forms available. Subsequently, iron-dextran* was tested in several litters.

This paper briefly discusses and compares the value of the two iron compounds in the treatment and prevention of piglet anaemia, and also includes a brief note on treatment with copper sulphate.

* An iron-dextran compound released by Benger Laboratories Ltd., Cheshire, under the name "Imferon" and containing 50 mg iron per ml as ferric hydroxide, was made available by the courtesy of Fisons Chemicals Ltd., Sydney.

II. PROCEDURE

A total of 111 Large White/Berkshire cross piglets in 14 litters, reared with their dams at this Institute, was used for this study. The piglets were housed in concrete pens 15 ft x 9 ft with no access to soil up to the weaning age of 6–8 weeks. The sows were fed a dry mixture, comprising crushed sorghum, wheat and maize, meatmeal, livermeal, lucerne chaff, dried buttermilk and bran, with added ground limestone, salt and a vitamin A supplement. The mixture contained 0·056–0·084 per cent. iron. The piglets had unrestricted access to the dam's feed and generally started to nibble some dry feed between the third and fourth weeks of age.

They were weighed at birth and in most cases weekly thereafter until weaning. Haemoglobin determinations were made in a Lumitron colorimeter on blood drawn from the anterior vena cava according to the technique of Carle and Dewhirst (1942). The haemoglobin level was taken as an indication of the iron status.

In 65 piglets, the first haemoglobin levels were determined on blood samples obtained at or within 12 hours of birth. In the remaining 46 piglets, it was done at the age of seven days. In a number of piglets the haemoglobin levels were followed at weekly intervals up to weaning, but in others the levels were recorded at irregular intervals, generally at least two or three weeks after iron supplementation.

Eighty-seven piglets were supplemented with iron. Twenty-five received one oral dose of 0·5 g *Ferri et Ammonii Citrate* (FAC) dissolved in 3 ml of water at two or three weeks of age. Five were given a prophylactic treatment of 0·3 g at the age of three days, followed by a second dose of 0·5 g two weeks later. Fifty-seven piglets were treated with a single injection of 2 ml iron-dextran intramuscularly, from the 8th to the 27th day. Included in this group were five which had received iron-dextran (ID) after an initial dosing with FAC (Litter No. 192). Two litters (Nos. 365 and 371) received iron-dextran prophylactically at the age of four days. The remaining piglets received treatment on the basis of their haemoglobin status.

In most cases treatment was delayed as long as possible to enable the pattern of the haemoglobin levels at various ages to be studied.

Twenty-four piglets were not treated. These comprised one litter of 10 (litter No. 38) and 2–4 untreated piglets from each of four further litters (Nos. 37–B, 190, 365 and 371).

Six piglets received an oral dose of 0·3 g copper sulphate in 2 ml of water a week before being treated with iron.

During the trial the piglets were observed for clinical evidence of anaemia.

III. RESULTS

The range and mean of body-weights and haemoglobin levels of individual litters are set out in Table 1.

Table 1

RANGE AND MEAN OF BODY-WEIGHTS (LB) AND HAEMOGLOBIN LEVELS (g%) OF PIGLETS

No. of Litter	Piglets in Group	Age (days) and Treatment	At Birth		Days after Birth: 4		7		14	
			Bwt.	Hb.	Bwt.	Hb.	Bwt.	Hb.	Bwt.	Hb.
37–A	7	21–FAC	3·2 2·7–3·6				5·9 4·4–6·9			
37–B	4	22–FAC	3·4 3·0–3·8	11·0 10·8–11·7			7·5 7·0–8·5	6·5 6·1–7·6	10·8 9·8–11·5	4·8 4·6–5·1
	4	nil	3·0 2·3–3·6	11·2 10·8–12·0			7·5 6·8–8·0	6·0 5·2–8·4	11·4 10·8–12·5	4·8 4·1–5·1
37–C	9	14–ID	2·7 2·3–3·5				5·2 4·0–6·5		6·4 4·4–8·5	5·6 4·6–6·8
38	10	nil	3·0 2·5–3·5	10·9 9·2–12·4			5·0 4·4–5·7	7·2 5·0–9·3	7·7 4·8–9·5	5·2 3·5–6·9
192	5	16–FAC	2·7	10·8			6·5	7·1	10·2	5·1
		37–ID	2·5–2·9	9·9–11·2			6·3–6·6	6·6–7·4	10·0–10·8	3·4–6·4
	5	3–FAC	2·8	10·4			6·4	8·6	10·1	6·9
		16–FAC	2·5–3·0	9·2–11·2			6·2–7·0	6·6–9·2	9·5–11·0	6·7–7·7
190	6	15–ID	3·1 2·4–3·6	11·1 9·1–12·4			6·3 5·0–7·3	6·6 5·5–7·7	9·7 7·7–11·2	4·6 4·1–5·4
	4	nil	3·3 3·1–3·8	10·9 9·5–11·7			6·4 6·2–6·8	6·8 6·7–8·3	10·1 9·8–10·7	5·4 5·2–5·7
149	6	16–ID	3·1 2·5–3·6				4·5 3·5–5·6	7·9 6·9–9·2	5·3 4·0–6·0	7·3 6·0–9·4
188	6	15–Cu	3·1	10·6			5·7	7·8	8·3	6·6
		22–ID	2·8–3·6	9·0–11·5			4·0–6·5	7·1–9·0	5·5–10·5	4·9–7·1
	4	15–ID	2·4 2·0–3·5	10·8 9·7–12·4			5·7 4·3–6·8	7·6 7·0–8·5	8·4 5·8–10·7	6·5 5·2–7·4
151	2	8–ID	3·1 2·8–3·4	11·6 11·4–11·8			5·9 5·3–6·5	7·2 6·7–7·8	9·8 9·5–10·0	9·8 9·4–10·2
	2	15–ID	2·7 2·1–3·2	11·2 10·4–11·4			5·3 4·5–6·0	9·1 8·3–9·9	9·0 8·3–9·8	6·6 6·6–6·6
154	9	17–ID	3·4 3·0–3·9				6·9 6·1–8·5		11·2 9·5–12·0	5·0 4·3–6·0
199	1	15–ID	2·5				5·3		9·0	3·2
	5	15–FAC	2·7 2·5–3·2				5·5 4·7–5·8		9·5 9·0–10·5	4·8 4·2–5·7
198	9	15–FAC	3·0 2·3–3·6						11·1 7·0–12·5	5·4 3·3–6·7
365	2	4 ID	3·0	12·2	3·8	8·6	5·6	9·2	9·2	10·6
			2·5–3·6	11·4–13·1	3·0–4·6	8·3–8·9	4·6–6·6	8·9–9·6	8·0–10·5	10·5–10·7
	2	nil	3·0 2·5–3·5	12·1 11·8–12·4	4·0 3·4–4·6	9·4 9·1–9·8	6·5 6·0–7·1	7·4 7·1–7·7	9·6 8·2–11·0	5·1 4·9–5·3
371	5	4–ID	3·0	12·5	3·6	8·8	5·1	9·3	8·1	10·9
			2·8–3·1	11·5–13·3	3·2–4·0	7·3–10·1	4·6–5·8	8·6–10·2	7·0–9·5	10·2–11·5
	4	nil	3·0 2·5–3·6	12·8 12·1–13·5	3·8 3·1–4·5	8·6 6·9–10·2	5·5 4·3–6·6	7·4 6·0–8·5	7·8 6·5–8·5	6·1 5·3–7·4

ID—Iron-dextran intramuscularly Cu—Copper sulphate orally

(a) Blood Haemoglobin

The haemoglobin levels at birth ranged from 9·0 to 13·5 g/100 ml. Sixteen piglets had levels over 12·0 g/100 ml. In 40 piglets the levels were between 10·0 and 11·9 g/100 ml and in nine from 9·0 to 9·9 g/100 ml.

Days after Birth												
21		28		35		42		49		56		
Bwt.	Hb.	Bwt.	Hb.	Bwt.	Hb.	Bwt.	Hb.	Bwt.	Hb.	Bwt.	Hb.	
	6·7 4·6–9·8	15·8 7·5–19·5			10·3 9·6–11·7		10·9 10·8–11·7		10·0 8·3–11·0			
14·5 13·0–16·0 16·8 13·5–19·5	4·1 3·9–4·3 4·6 4·0–5·2	18·4 16·5–20·0 19·0 16·8–20·3	7·1 5·4–8·6 5·9 5·4–6·5	23·2 21·0–24·8 23·2 21·5–24·3	8·7 8·2–9·9 8·0 6·7–8·8	30·5 24·5–36·0 28·2 26·5–29·5	10·5 9·5–11·4 10·0 9·5–10·5					
		14·2 7·5–15·5	9·2 4·6–10·2							33·6 28·0–37·0		
11·1 7·5–13·5	4·2 2·8–5·9	13·5 8·5–16·5	3·5 2·2–4·9	15·6 11·8–18·0	4·6 2·1–6·9	20·7 15·8–25·5	6·1 3·7–9·0	26·2 21·5–31·8	6·7 4·5–10·6			
13·1 11·8–14·5 13·3 12·5–15·0	6·2 5·2–6·8 7·1 6·3–7·8	16·0 15·5–17·7 17·2 16·2–17·8	6·1 4·7–7·1 6·6 6·1–6·8	19·2 18·0–20·7 20·9 18·5–22·5	5·7 5·1–6·6 7·1 6·6–7·8	22·5 20·5–24·2 22·7 21·5–24·5	9·4 8·7–10·7 7·0 6·2–8·5	29·4 27·0–31·0 26·5 23·3–29·7	12·0 11·4–12·4 10·1 7·1–11·2			
11·8 10·0–12·5 12·5 12·0–13·0	8·7 8·2–10·7 5·9 5·5–6·6	13·9 11·0–15·5 14·6 12·6–16·8	10·0 9·0–11·7 7·4 6·9–8·4	18·4 15·7–20·3 19·0 16·5–22·5	10·1 8·4–11·5 7·8 6·7–10·5	22·5 19·5–25·3 23·2 20·0–29·5	11·5 10·5–12·4 9·0 6·0–12·0	28·5 25·5–32·0 29·0– 25·0–37·0	12·2 11·4–13·8 10·1 5·6–13·5			
7·7 4·0–8·5		9·3 5·5–11·3	11·5 10·7–12·2					22·1 16·0–26·5				
12·7 5·3–14·2 10·7 7·5–15·0	5·5 4·3–6·9 9·0 8·2–9·5	13·9 7·0–17·5 14·0 9·3–19·5	9·0 6·0–10·7 9·6 8·2–10·6	17·4 9·5–21·0 17·6 12·0–23·5	9·5 7·9–10·8 9·5 8·7–11·0	23·3 13·5–27·8 22·5 16·7–29·5	10·8 8·6–12·9 9·9 9·0–11·5	24·1 16·5–32·5 26·0 20·0–32·0	11·1 9·4–12·9 10·8 10·0–11·7			
15·0 14·5–15·5 12·8 12·5–13·0	9·6 9·4–9·9 9·3 9·2–9·4	19·3 18·5–20·0 17·0 17·0–17·0	8·3 8·0–8·6 9·3 9·1–9·4	24·6 23·5–25·8 21·2 21·0–21·3	7·8 7·1–8·6 9·3 9·1–9·4	29·5 28·0–31·0 26·0 25·5–26·5	7·9 7·3–8·6 9·0 7·8–10·3	35·5 32·5–38·5 31·8 30·0–32·5	8·8 7·8–9·7 10·0 8·4–11·7			
		17·5 15·6–18·8	9·1 7·9–10·3							32·4 25·0–35·0		
		16·0 19·5 18·5–20·5	9·6 6·4 4·0–7·1							29·0 34·4 30·5–36·5		
		16·0 13·5–19·0	5·1 3·4–7·0					31·2 24·5–36·0				
14·2 13·5–15·0 12·9 10·8–15·0	8·8 8·6–9·0 3·8 3·6–4·0	18·4 17·8–19·0 16·8 15·0–18·5	7·6 7·3–7·9 4·1 4·0–4·2	24·8 24·5–25·0 21·5 20·0–23·0	8·0 6·8–9·3 4·8 4·7–5·0	27·8 27·0–28·5 24·8 24·5–25·0	8·4 6·2–8·6 5·4 5·3–5·5	31·7 30·5–33·0 28·8 28·5–29·0	9·8 9·6–10·0 8·4 8·2–8·6	39·5 38·5–40·5 26·8 36·5–37·0	12·4 12·4–12·4 11·1 11·0–11·2	
11·6 10·3–13·8 10·6 8·5–12·0	11·6 10·2–13·1 6·8 4·4–9·4	15·7 12·8–18·5 13·2 11·5–15·0	11·0 9·5–12·8 7·0 4·9–10·2	19·5 16·5–21·5 18·0 15·5–19·0	10·8 9·6–12·2 7·6 4·9–10·2	26·0 22·0–28·5 22·2 22·0–23·0	10·4 9·2–12·2 7·8 5·0–10·5	34·4 29·5–38·5 28·4 27·5–29·0	10·8 10·2–12·2 10·9 8·1–14·0	39·7 34·5–44·5 34·2 32·5–36·0	12·1 11·2–13·1 10·9 10·3–12·0	

FAC—*Ferri et Ammonii Citrate* orally

In the 24 untreated piglets there was a steady and marked decline of the blood haemoglobin in the first three weeks of life. In many the levels had dropped within a week after birth by 30 per cent. or more. Observations on two litters (Nos. 365 and 371) indicated that this decline occurs within a few days after birth. At the end of the second week the levels often were only half or even less of their birth levels. The decline usually continued up to the fourth week, occasionally reaching a figure of 3 g/100 ml or less. Thereafter, the haemoglobin levels generally showed a tendency to increase slowly. Though in occasional piglets there was a more sudden rise just before weaning, the levels usually remained low.

The lowest levels reached in the piglets were 1·5, 2·2 and 2·8 g/100 ml respectively in one untreated litter (No. 38). The level of 1·5 g/100 ml haemoglobin was recorded in a pig on the 39th day after birth. It died the following day. The remaining two figures were recorded in two piglets on the 28th day. They improved gradually, although their haemoglobin levels at seven weeks were still only 4·5 and 6·0 g/100 ml respectively.

In two litters, Nos. 37A and 37B, a single oral dose of 0·5 g FAC apparently gave satisfactory results as judged by the post-treatment rise of haemoglobin two weeks later. This rise was noticeable, especially in piglets which had the lowest pre-treatment readings. In the other treated litters the response was disappointing. Even when prophylactic treatment at three days was followed by a further treatment at two weeks, the birth levels of haemoglobin were not restored. However, they quickly responded to iron-dextran treatment (Table 1).

Of the 57 piglets treated with iron-dextran, 50 were medicated at the stage where the haemoglobin levels indicated an advanced state of anaemia.

With one exception (one piglet in litter 37C) iron-dextran had a marked effect on the post-treatment haemoglobin levels. In most cases the levels rose by 30–50 per cent. within a week. In many instances the pre-treatment level was doubled, especially when the levels at the time of treatment were less than 5 g/100 ml. Usually the rise continued at a somewhat slower rate thereafter until weaning. In a number of piglets, however, after an initial rise the levels became more or less stationary until a further rise occurred just before weaning. In one group (No. 151) of four, where the levels at the time of treatment were only moderately low, i.e. 6·6–7·8 g/100 ml, the haemoglobin after an initial rise in three of these began to decline slowly some two weeks after treatment, and rose again slightly before weaning.

Administration of iron-dextran at the fourth day of life quickly restored the haemoglobin to satisfactory levels with a peak about two weeks later. It is of interest that iron-dextran restored the birth level in only one of the seven treated

piglets, while in the six others the levels remained somewhat lower. After the peak was reached, a mild secondary decline became evident, but recovery followed as soon as the piglets started to consume dry feed mixture in sufficient quantity. At the weaning age of eight weeks the haemoglobin levels were comparable with those at birth.

A single oral dose of copper sulphate failed to arrest the decline of haemoglobin in a group of six piglets in one litter (No. 188), but administration of iron-dextran one week later produced rapid improvement.

(b) Symptomatology and Pathology

The most common clinical evidence of iron deficiency was diarrhoea characterized by pasty to liquid, whitish, creamy to yellowish faeces in a variable number of piglets in each litter. With the exception of two litters (Nos. 38 and 192) no other symptoms were noticed clinically, although the haemoglobin levels in some piglets fell to 3·2 g/100 ml.

In the untreated litter No. 38, several piglets showed extreme pallor, listlessness and rapid respiration between the fourth and fifth weeks of age, and one piglet died. It had a haemoglobin level of 2·1 g/100 ml on the fourth day preceding death and 1·5 g/100 ml one day before death. It showed congestion of the liver and severe myocardial degeneration.

In litter 192, three piglets before iron supplementation showed a slightly laboured respiration. The haemoglobin levels of these piglets ranged from 4·7 to 6·5 g/100 ml.

In general, scouring in all litters coincided with low haemoglobin levels and lasted, if not medicated, for 5–7 days or longer. Iron supplementation shortened this time, so that with iron-dextran the faeces became normal again within 1–3 days. After treatment with FAC, faeces returned to normal in three days at the earliest, but in some piglets scouring persisted for six days.

In litter No. 37C, scouring which had persisted for nine days in several piglets despite oral medication of 0·5 g oxytetracyline* daily for three days disappeared within 24 hours after the use of iron-dextran.

* "Terramycin—Animal Formula Soluble Powder" by Chas. Pfizer & Co., Inc., Brooklyn, N.Y.

(c) Body-weights

Birth weight apparently had no influence on the incidence of anaemia. However, there was some indication that at the critical age of 2–3 weeks lower haemoglobin levels appeared to be more common in piglets that had made more rapid weight gains, though occasionally the reverse was true.

Although the experiment was not designed to determine the influence of iron therapy on weight gains, statistical analysis of the results supported the conclusion that iron-dextran and FAC both improved the rate of gain if they were administered early. Table 1 shows that with the exception of litter No. 190 the mean body-weights of piglets treated with iron-dextran were at weaning 2·7–5·5 lb more than the weights of untreated piglets in the same litters. In litter No. 190 the mean weight of the controls was half-a-pound more than that of the supplemented pigs but the figures were unduly influenced by one very heavy pig in this group. The mean growth rate of the supplemented group was faster than that of the controls (statistically significant at the 5 per cent. probability level). Treatment with iron-dextran at seven days was also superior to treatment at 14 days (significant at the 5 per cent. level).

IV. DISCUSSION

Anaemia is common in piglets submitted to this Institute for diagnostic purposes. This applies not only to piglets reared on impervious floors but also to those with access to soil. Haemoglobin levels of only 6–7 g/100 ml have been recorded in piglets even up to 12 weeks old.

Observations at the Institute have shown that the haemoglobin levels in piglets reared on concrete floors decline very rapidly within a few days after birth in spite of good nutrition and husbandry. The decline usually continues to the end of the second or third week. After this time the levels frequently have fallen to less than half of the values at birth, e.g. 5 g/100 ml or less. Diarrhoea is a common clinical sign at this stage, although it may occur also when the decline is less pronounced. Anaemia may also be evident. Disinclination to move and respiratory embarrassment appear when the levels reach 3 g/100 ml or less, though in one litter it became evident at haemoglobin levels around 5 g/100 ml. Several workers (Kernkamp 1935; McDonald, Dunlop, and Bates 1955) expect clinical signs of the disease as a result of anaemia to develop when the haemoglobin levels decrease by more than 30 per cent. of the birth values. According to Baskett and Lamont (1936), death is to be expected at levels between 3 and 4 g/100 ml, while Kernkamp (1935) regarded 2·5 g/100 ml as a critical level. In experience at the Institute, however, even at this level piglets did not always succumb but recovered gradually. Under poor husbandry conditions, these levels might have proved critical.

After reaching the lowpoint, the haemoglobin levels generally improved slowly from the third week of age onwards, coinciding with increasing intake of dry pig-feed. Generally, a sharper rise in haemoglobin levels in untreated piglets was evident at the age of seven weeks, when the piglets were consuming a considerable amount of dry feed mixture. The rise in haemoglobin levels at this stage was probably due to the iron contained in the feed. Sow's milk is a poor source of nutritional iron, and it is considered not to supply more than about 1 mg Fe per day per sucking pig of the daily requirement of 7 mg (Venn, McCance, and Widdowson 1947) to 15 mg (National Research Council 1950, cited by Barber *et al.* 1955) for the growing piglet in the first three weeks of life in order to maintain normal haemoglobin levels.

The observations strongly indicate that iron-supplemented creep feeding should be introduced early and preferably between two and three weeks of age.

Iron therapy in the form of oral dosing of individual piglets with a mixture of ferrous sulphate, copper sulphate and molasses, or the application of this mixture to the sow's udder, as recommended in this part of Queensland, leaves much to be desired. Experiments with FAC have shown that a single dose of 0·5 g (supplying about 100 mg Fe) of this compound also is of limited value only. Intramuscular injection of 2 ml iron-dextran, however, proved to be remarkably effective in raising the haemoglobin levels and is considered to be a highly effective method in the treatment and prevention of piglet anaemia.

In view of the results of Barber *et al.* (1958) and Dale and MacKay (1958), who showed that although repeated injection of iron-dextran gave an enhanced haemoglobin curve, no significant differences were obtained in body weights at weaning, the need for more than one treatment does not appear to be justifiable. It is essential that treatment should be given early, within 3 or 4 days after farrowing, in order to carry the piglets over the critical period and until such time as the creep feeding will supply the iron supplement.

Toxic hazards are most unlikely to be encountered in the course of iron-dextran medication. One report only of toxic effects has been published (Behrens 1957). None occurred in our trial.

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FILTRATION OF CREAM FOR BUTTERMAKING

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SUMMARY

An appreciable reduction of the amount of extraneous matter in butter, as reflected by routine tests for extraneous matter on samples examined in the laboratory, has occurred in Queensland butter factories. This has resulted from the use of cream filtration equipment in factories during the past two years. The paper reports investigations which resulted in satisfactory methods for the filtration of cream in factories. It gives details of experiments with nylon filter cloths of varying pore size and the filtration of cream, prior to and after pasteurization, with commercially available and improvised types of cream filtration equipment. Nylon cloth of 75–100μ pore size was practicable for factory conditions and better results were obtained by filtering cream before pasteurization.

I. INTRODUCTION

The use of nap filter cloth normally used for the filtration of milk is unsuitable for the filtration of cream as the cloth soon becomes fat-saturated and clogs.

In previous work carried out in Queensland (Crittall 1958), it was shown in a limited number of tests that extraneous matter could be removed satisfactorily from cream by filtration through nylon cloth. This work has since been extended to cover a wider range of filter types and varieties of filter cloth. Because of the effect of protein precipitates blocking the filters following pasteurization, a repositioning of the filtering equipment in relation to the other cream processing equipment has been examined.

II. METHODS OF FILTRATION

Much interest in the filtration of cream has been aroused within the butter industry in Queensland because of the introduction of export regulations requiring all cream to be filtered prior to manufacture into butter. This has resulted in many attempts to improvise filters which are cheap and easy to maintain. The work reported here has been concerned with three commercial filters, representing both stocking and plate types, and a number of improvisations which have been evolved in individual factories.

(a) Commercial Filters

A general description of both stocking and plate-type filters has been given previously (Crittall 1958). In the case of the stocking or chamber type, a modification has been made in one commercial type by incorporating a fine

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metal gauze strainer, situated before the filter, to effect removal of the coarser material. Subsequently, a further modification was introduced by the replacement of the gauze by a perforated stainless steel sheeting with perforations $\frac{1}{16}$ in. in diameter. The latter modification was carried out in an attempt to effect easier cleaning of the filter.

(b) Improvised Filters

Various types of improvised cream filters have been tried by many butter factories. These fall broadly into two types—a cloth stocking fitted over the end of a pipeline, and a cloth bag lining the inside of the cream balance tank. Whereas earlier these filters used a cotton cloth, the success demonstrated with nylon material soon brought about the discarding of cotton in favour of nylon for most stocking or bag-type filters.

Some of the improvised filters used in factories are shown in Figures 1–4. Figure 1 shows a large nylon bag lining the inside of the balance tank between the vacreator and the plate cooler in a Queensland factory. The area of this cloth is 11–12 sq. ft, and up to 4,000 gal of cream have been filtered without the material becoming too clogged to maintain an efficient throughput of cream. Where no such balance tank is used, as at factories which cool cream by means of a surface cooler, two nylon bags tied on the distributing line at the top of the surface cooler may be used. This device as used in a Queensland factory is shown in Figure 2. A rather more complicated device is being used at one factory in Queensland (Figures 3–5). To minimise the strain on the material, the nylon is supported in a metal gauze cylinder.

(c) Nylon Filter Cloths

Considerable attention has been paid to ascertaining the most suitable weave and mesh size of nylon for the efficient filtration of cream. In this regard, two factors are involved, namely, maintenance of desirable throughput without creating too high back pressure, and the removal of as much extraneous matter as possible. These two factors are inter-related in the choice of suitable cloth.

Initially, suitable nylon weaves could not readily be obtained in Australia, and six different screening cloths were imported from manufacturers in the United States and three from sources in the United Kingdom. In these cloths the mesh sizes varied from 20 μ to 120 μ, measured as the average width of the filtering opening in each. All but one were multifilament weaves.

Fig. 1

Large nylon bag lining the inside of the balance tank between the vacreator and the plate cooler.

Fig. 2

Two nylon bags tied on the distributing line at the top of the surface cooler.

Fig. 3.

Showing support for nylon bag in balance tank.

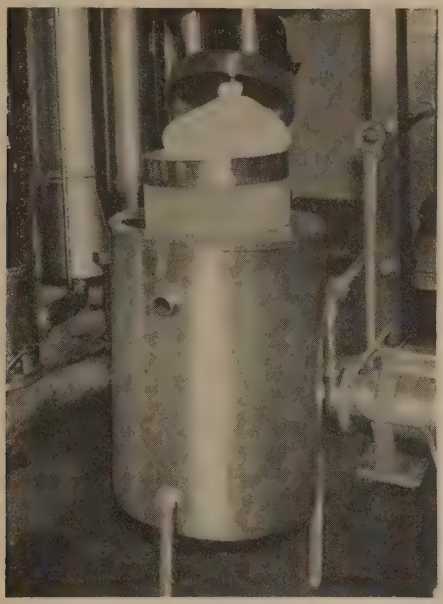

Fig. 4
Nylon bag attached.

From the point of view of efficiency of removal of extraneous matter, it would be expected that the finer cloths would be more suitable. Generally, this was found to be so, but the use of excessively fine pore sizes caused early clogging of the interstices with resultant low throughput and necessity for frequent changing of the cloths. Some materials procured locally and having pore sizes as high as 200 μ were also examined. These gave reasonably satisfactory results when the rate of sampling was not great. Where, however, the number of samples taken per churning of butter was increased, evidence of extraneous matter let-through was obtained. This raises the matter of the importance of sampling procedures in any work of this nature, a matter which is discussed elsewhere in this paper.

Results obtained in tests on butter manufactured from cream filtered through cloths of various pore sizes have indicated that a very small pore size is unnecessary for overall filtering efficiency. In this work three types of multi-weave cloths with approximate pore sizes of 40–60 μ, 70–75 μ, and 90–100 μ were used. After more than 500 tests had been carried out it became apparent that the efficiency of filtration with each of the three mesh sizes was not significantly different. The results indicated that a pore size as high as 100 μ

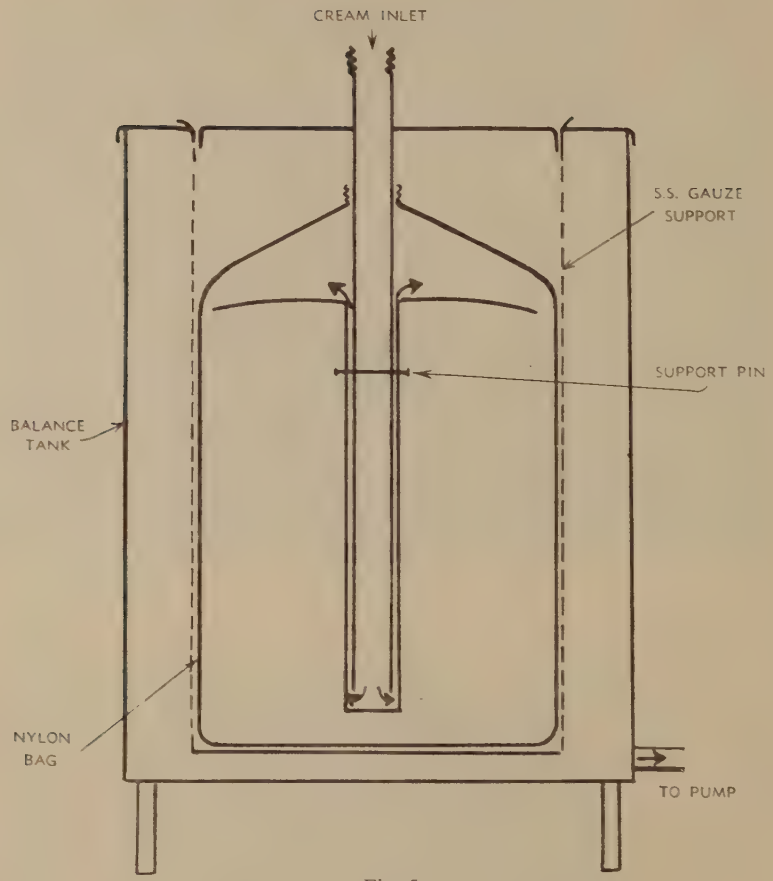

Fig. 5

Diagram showing how nylon bag is suspended in balance tank.

can be safely employed. With cloth of this pore size, a good throughput of cream is obtained. During this trial the frequency of sampling was kept approximately constant at the rate of one sample to each three boxes of butter manufactured, which is far in excess of the routine rate in testing laboratories of one sample per churn-load of butter.

III. POSITION OF FILTER

(a) Filtration After Pasteurization

Filtration of cream after pasteurization did not give entirely satisfactory results. There were a number of reasons for this.

In early trials with a stocking-type filter, installed between the balance tank and the cooler, so that the cream is filtered after pasteurization, considerable trouble occurred through breakage of the cloths. This was due to the fairly high pump pressures which resulted from clogging of the cloth itself. However, this was not always the cause of breakage of the cloths, because at times the nylon stocking was broken when bumped against sharp metal edges during careless assembly of a one-stocking-type filter. Breakage of cloths was more evident in this filter than in a plate-type or a double-stocking-type filter.

Observations made on the operation of stocking-type filters (40–60 μ mesh opening) used after the cream had been treated in a vacreator showed that filtration was satisfactory for a period of two to three hours; during this time approximately 1,000 gal of cream passed through one leg of the filter before a sock was changed. Then, rather suddenly, a blockage occurred, and on changing to a clean sock, instantaneous blockage of this sock also occurred. Sediment tests, using lintine filter discs, were attempted on cream sampled at this stage of processing. Normally, no difficulty was experienced in performing such tests, but with this cream it was impossible to force it through the filter disc. These blockages were due to the formation of a gelatinous substance during heat treatment of cream in the vacreator, and not to inefficient washing of the stocking. A coarser cloth (approximately 100–120 μ mesh) permitted a satisfactory flow rate of cream. As well as this gelatinous substance in the vacreated cream, scale-like residues were found on the filter cloths. Particles of this scale varied in size from a fine powder to small flakes about $\frac{1}{4}$ in. long and the quantity increased whenever cream was again treated after the vacreator was stopped for any reason.

As the amount of scale and dirt in the filter increased pressures were recorded on the pressure gauge attached to the filter, the differential pressure sometimes reaching 25 lb per sq. in. These pressures were excessive and could be responsible for forcing the fine scale into the pores of the filtering medium with resultant clogging or bursting. In order to reduce the pump pressure, the filter was still placed after the vacreator, but on the suction side of the pump rather than on the discharge side, as previously. In order to achieve this, the balance tank had to be raised about 3 ft and the filter placed in an almost horizontal position. With the filter in this position it was found that there was less fracturing of threads of the nylon socks, but, as would be expected, there was no improvement in throughput and, as a pressure gauge cannot be used here, it was difficult to judge when the sock was becoming clogged.

(b) Filtration Before Vacreation

In order to overcome these difficulties it was decided to place the filter before the vacreator and filter the cream before pasteurization. The cream filtered at this stage had been pre-heated either by means of a steam injector in the cream line between the neutralizing vats and the vacreator, or by steam introduced directly into the cream in the neutralizing vats. Although this latter practice cannot be recommended, the factory where this trial was performed has been pre-heating cream in this manner for several years without any apparent detrimental effects. It is thought that these methods of pre-heating could cause increased fat losses during the churning of cream, a matter which is being investigated.

The temperature of the cream after pre-heating was usually 105–110°F but varied from 80°F to 120°F. In the two factories where cream was filtered before pasteurization, pressure heads were fitted to the vacreators to enable high-temperature cream treatment.

Various nylon cloths with mesh openings of 40–60 μ, 70–75 μ, 90–100 μ and 150–200 μ were tried. Good throughput was obtained with all cloths in both plate and stocking-type filters. In one stocking-type filter tested, the effective area of cloth available for filtration varied from 2 sq. ft to 4 sq. ft, depending on whether the diameter of the sock was large enough for it to be supported by the exterior stainless steel perforated plate, which blanked off approximately 50 per cent. of the cloth. In this case, consistent runs of 1,000 gal of cream per leg were recorded when 40–60 μ mesh cloth was used, and with 70–75 μ mesh cloth it was possible to filter 2,000 gal of cream before a changeover of filter cloths was necessary. With a 24-plate commercial filter the effective filter area of cloth was 15 sq. ft, and using a cloth with a porosity of 75 μ, 4,000–5,000 gal of cream were usually filtered satisfactorily, although on one occasion when the cream was rather dirty, the maximum was barely 4,000 gal.

In some factories, where cream is filtered before pasteurization, a fine-gauze strainer is placed in the balance tank installed after the pasteurizer to collect the larger scale particles. At present 40-mesh stainless steel gauze is in use, but 60-80-mesh would not be too fine. Although the presence of such scale in the butter does not incur any penalty insofar as extraneous matter is concerned, it may have an effect on the bacterial development in the butter, and it is better removed. Regular inspection of the balance tank will reveal whether the filter cloth has become torn, as extraneous matter can then be seen floating on the cream in the balance tank.

IV. CLEANING OF CLOTHS

The nylon cloths have been most satisfactorily washed in the following manner: Rinse off excess cream with warm water, socks having been turned inside out. Wash in hot detergent solution by rubbing material against itself. Rinse in warm or hot water.

It was observed that nylon used in a filter positioned before the pasteurizer is more readily cleaned than that used in a filter after pasteurization. In the latter case, the cloths may appear clean, but a fine dust-like deposit is occasionally noticed after the cloth has dried out.

If cream is filtered after pasteurization, the filter cloths need to be sterilized by such means as soaking in a sodium hypochlorite solution (approximately 200 p.p.m.) and pre-filtration contamination must be avoided. This is not so important if cream is filtered before pasteurization.

V. RESULTS OF TESTS

Between January 1956 and March 31, 1959, over 6,000 routine tests for extraneous matter in butter were performed and the filter discs examined. The classification of Lawrence (1951) and a modification of his method were used for these tests. Figure 6 shows the percentage of butters in each quarter of the year which were classified as "dirty" or "very dirty". It will be seen that there has been a steady reduction in the quantity of extraneous matter found in butter, and there seems to be a seasonal factor associated with its incidence. The percentages of samples classified as "dirty" were highest in the April-June months. Most Queensland butter factories have installed some cream filtration device, and this action has been responsible for reduction in extraneous matter in Queensland butter.

Fig. 6

Incidence of extraneous matter in butter, showing reduction since factories began to filter cream.

The results of tests made from 102 samples of butter during a period of 15 months from one factory where a nylon bag was fitted to the end of the pipeline in the balance tank placed after the pasteurizer were as follows:—

—	Clean	Fairly Clean	Dirty	Very Dirty
Number of tests	30	69	3	0
Percentage ..	29·4	67·9	2·9	0

VI. DISCUSSION

Results of over 6,000 extraneous matter tests made on samples of butters have shown that cream can be filtered satisfactorily to give a "clean" or "fairly clean" extraneous matter disc. The efficiency of filtration of cream naturally depends on the openness of the cloth used, and it has been found that nylon cloth of 75 -100 μ pore size is most practicable. With commercial filters better results were obtained by filtration of cream pre-warmed to approximately 105°F prior to pasteurization. Some makeshift filtration devices are satisfactory, provided the nylon sock or bag is supported in some way; otherwise, there is a greater risk of the material bursting.

The sample of butter taken for the extraneous matter test is only 15 g, a very small quantity in comparison with that produced from a churning of butter, which may be as much as 2½ tons. It is realised, however, that in the case of export butter the size of the sample which can be taken is limited. This should be borne in mind when an extraneous matter test of butter is being made, and a decision on its classification by the extraneous matter test would be better based on results from a series of tests rather than on an individual test.

VII. ACKNOWLEDGEMENTS

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TECHNICAL NOTES

INSECTICIDAL CONTROL OF HELIOTHIS IN LINSEED

Two species of Heliothis attack linseed in Queensland; *Heliothis punctigera* Wallengr. predominates in southern districts, and occurs in about equal numbers with *H. armigera* (Hubn.) on the Central Highlands.

Three trials, with plot size of 1/100 ac, were carried through; two at Capella, Central Highlands, during 1957 and 1959, and one on the Darling Downs in 1958. Randomized block designs of 5 × 5 and 8 × 3 were used for the first two, and a factorial block of 4 DDT and 3 diazinon levels with 3 replications in the third trial. Materials used were an emulsion concentrate of DDT containing 25 per cent. w/v p,p' isomer, and a diazinon concentrate containing 20 per cent. active ingredient. Sprays were applied with a hand-operated power unit at 200 gal/ac in the 1957 trial, and at 100 gal/ac in the others. Additional details are given in tables of results.

These results demonstrate that treatments of 1 lb and ½ lb of DDT per ac, when applications are thorough, give comparable kills. Results of Trials 1 and 2 (Tables 1 and 2) point out the importance of correct timing of insecticide application; Table 2 stresses the value of early treatment. In Trial 1 reinfestation occurred after treatment and the crop was practically a total loss (Table 1—column headed 12.xi.57). Reinfestation seldom occurs in southern districts.

There is no evidence that the presence of two species of Heliothis in linseed is a factor in control.

Table 1

RESULTS OF 1957 TRIAL, CAPELLA

(Pest Survivals and Boll Damage)

Treatment	Mean Number of Larvae (30 ft of row per plot)			Mean Number of Damaged Bolls in a 300 Random Sample per Plot	
	Pre-treatment	Post-treatment			
	26.ix.57	27.ix.57	7.x.57	7.x.57	12.xi.57
DDT 1 lb/ac	21·8	0·6	13·4	100·8	266·8
DDT ¾ lb/ac	20·0	1·0	13·0	105·2	268·4
DDT ½ lb/ac	17·4	1·0	34·4	121·4	285·6
DDT ¼ lb/ac	15·8	2·6	54·0	144·6	276·0
Check	24·4	25·0	42·6	281·4	297·2

Table 2

RESULTS OF 1958 TRIAL, DARLING DOWNS

(*Pest Survivals and Yields*)

Treatment	Mean Number of Larvae (36 ft of row per plot)		Yield
	21.x.58	28.x.58	Mean (lb/plot)
DDT 1 lb/ac on Oct. 15 (10 days after peak flowering)	0	1·5	4·11
DDT ½ lb/ac on Oct. 15	1·0	5·0	3·80
DDT 1 lb/ac on Oct. 21	37·0*	1·0	3·36
DDT ½ lb/ac on Oct. 21	36·5*	1·8	3·17
DDT 1 lb/ac on Oct. 21 and repeated on Oct. 28 ..	34·8*	1·0	3·48
DDT ½ lb/ac on Oct. 21 and repeated on Oct. 28 ..	35·5*	2·3	3·31
Check—mean of two	36·5*	41·5	2·87
Necessary differences for significances among treatments 5%			0·61
Necessary differences for significances among treatments 1%			0·83
Necessary differences for significance for comparison involving check 5%			0·53
Necessary differences for significance for comparison involving check 1%			0·72

* Pre-treatment counts.

Table 3

RESULTS OF 1959 TRIAL

(*Pest Survivals and Boll Damage*)

Mean number of larvae (30 ft of row per plot)

48 hr after treatment—Sept. 18

	Transformed mean $(\sqrt{x+\frac{1}{2}})$					Actual Mean				
	DDT (lb/ac)					DDT (lb/ac)				
	0	½	⅔	1	Mean	0	½	⅔	1	Mean
Diazinon (oz/ac) 0	3·16	1·56	1·35	1·00	1·77	9·5	1·9	1·3	0·5	2·6
Diazinon (oz/ac) 2	2·43	1·55	1·97	1·47	1·85	5·4	1·9	3·4	1·7	2·9
Diazinon (oz/ac) 4	3·16	2·26	1·34	1·17	1·98	9·5	4·6	1·3	0·9	3·4
Mean	2·92	1·79	1·55	1·21	1·87	8·0	2·7	1·9	1·0	3·0

—	DDT	Diazinon	Individual
Necessary differences for significance 5%	0·61	0·53	1·06
Necessary differences for significance 1%	0·83	0·72	1·44

DDT : ½, ⅔, 1<<0

Table 3—*continued*

ONE WEEK AFTER TREATMENT—SEPT. 22

—		Transformed mean ($\sqrt{x+\frac{1}{8}}$) DDT (lb/ac)					Actual Mean DDT (lb/ac)				
		0	$\frac{1}{8}$	$\frac{2}{8}$	1	Mean	0	$\frac{1}{8}$	$\frac{2}{8}$	1	Mean
Diazinon (oz/ac)	0	1·94	1·27	1·00	0·71	1·23	3·3	1·1	0·5	0·0	1·0
	2	1·56	1·05	1·05	0·88	1·13	1·9	0·6	0·6	0·3	0·8
	4	1·93	0·88	1·10	1·05	1·24	3·2	0·3	0·7	0·6	1·0
Mean		1·81	1·07	1·05	0·88	1·20	2·8	0·6	0·6	0·3	0·9

—		DDT	Diazinon	Individual
Necessary differences for significance	5%	0·38	0·33	0·65
	1%	0·51	0·44	0·89

DDT : $\frac{1}{8}$, $\frac{2}{8}$, 1<<0

Table 4

RESULTS OF 1959 TRIAL

(Mean number of damaged bolls in a 100 random sample per plot)

Eight weeks after treatment—Sept. 18

—		Transformed mean (inverse sine) DDT (lb/ac)					Equivalent (%) DDT (lb/ac)				
		0	$\frac{1}{8}$	$\frac{2}{8}$	1	Mean	0	$\frac{1}{8}$	$\frac{2}{8}$	1	Mean
Diazinon (oz/ac)	0	21·53	18·33	12·73	5·40	14·50	13·5	9·9	4·9	0·9	6·3
	2	21·87	14·13	17·43	15·30	17·18	13·9	6·0	9·0	7·0	8·7
	4	26·87	22·50	13·07	13·33	18·94	20·4	14·7	5·1	5·3	10·5
Mean		23·42	18·32	14·41	11·34	16·88	15·8	9·9	6·2	3·9	8·4

—		DDT	Diazinon	Individual
Necessary differences for significance	5%	5·81	5·03	10·07
	1%	7·90	6·84	13·68

DDT : $\frac{2}{8}$, 1>>0
1>>$\frac{1}{8}$

These trial results and field experience are the basis for the extension article by Passlow and May (1960), which differs only slightly from that by Passlow (1952). These differences are due partly to the increased acreage of linseed on the Central Highlands during the past few years.

A point of interest is the inclusion of diazinon in the 1959 trial. In Queensland, when hot, dry springs occur the commercial control of Heliothis with insecticides is difficult, and a common approach under these conditions is to try insecticides other than DDT or additional to DDT. The 1957 season was of this type and a DDT–diazinon mixture was suggested; results (Tables 3 and 4) clearly demonstrate that diazinon has no value in the control of Heliothis in linseed.

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THE INSECTICIDAL VALUES OF TWO ISOMERS OF DDD

Following trials with DDD (TDE) for the control of the lucerne leaf roller (*Tortrix divulsana* (Walk.)) in the Lockyer Valley (to be published), the question of the relative toxicities of the *p.p'* and *o.p'* isomers arose. Technical grade DDD available in Queensland at the time was formulated as 30 per cent. total isomers, 20 per cent. being *p.p'* and the remaining 10 per cent. mostly the *o.p'* isomer. Overseas literature (Riemschneider 1950) indicates that the order of decreasing efficaciousness of DDD isomers is *p.p', m.p', o.p', o.m', and o.o'*.

During 1957, two trials each a 5 × 4 layout with plot size of 1/100 ac were established. Four samples of DDD with 30 per cent. total isomers were formulated with the same solvent and emulsifier. All differed, however, in the ratio of *p.p'* to *o.p'*. The dosage rate was 1 lb of total isomers in 100 gal per ac. Treatments were applied on April 23 (Trial 1) and September 11 (Trial 2). Pest populations were assessed from twelve ½ sq. yd. quadrats per plot. Results are presented in Table 1.

Table 1

RESULTS OF 1957 TRIALS : LARVAL COUNTS

Treatment	Trial 1		Trial 2	
	Pre-treatment (22.iv.57)	Post-treatment (28.iv.57)	Pre-treatment (10.ix.57)	Post-treatment (51.ix.57)
A. 27% p.p', 3% o.p'	1,543	55	1,006	1
B. 20% p.p', 10% o.p'	1,577	30	1,116	1
C. 13% p.p', 17% o.p'	1,706	33	1,052	1
D. 6% p.p', 23% o.p'	1,634	87	1,113	1
E. Untreated	1,729	683	1,053	430

All treatments were better than untreated, with no significant differences among treatments.

Using similar methods, a third trial was established in 1958. Dosage rate for treatment A was 1 lb per ac total isomers, and for treatments B–E ½ lb per ac. Treatments were applied on October 30. Results are presented in Table 2.

Table 2

RESULTS OF 1958 TRIAL : LARVAL COUNTS

Treatment	Pre-treatment (29.x.58)	Post-treatment (5.xi.58)	Significantly exceeds	
			5% Level	1% Level
A. 27% p.p′, 3% o.p′	843	14	B–E	C–E
B. 27% p.p′, 3% o.p′	963	82	C–E	D–E
C. 20% p.p′, 1% o.p′	930	173	E	E
D. 13% p.p′, 17% o.p′	1,009	278	E	E
E. 6% p.p′, 23% o.p′	846	593		
F. Untreated	(not used in analysis)			

All treatments were obviously better than untreated, and with the lower dosage rate significant differences among treatments were obtained. Survival of larvae increased as *p.p′* isomer content decreased. This isomer therefore is the important active constituent of technical DDD, which is used in Queensland mainly for control of tortricids.

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